Report for 2002TX58B: Real-Time Distributed Runoff Estimation Using NEXRAD Precipitation Data

- unclassified:
  - Hadley, Jennifer. Near Real-Time Runoff Estimation Using Spatially Distributed Radar Rainfall Data. Texas Water Resources Institute SR-2003-015.

Report Follows:

Real-Time Distributed Runoff Estimation Using NEXRAD Precipitation Data
Progress Report by
Jennifer Hadley, Forest Science Department, TAMU

The objective of this study is to develop near real-time runoff estimation for Texas using precipitation data from the Next Generation Weather Radar (NEXRAD) network. This will provide information useful for flood mitigation, reservoir operation, and watershed and water resource management practices.

Materials and Methods

The datasets used in this analysis were the USGS Multi-Resolution Land Characteristic (MRLC) dataset, the USDA-NRCS State Soil Geographic Database (STATSGO), and the Next Generation Weather Radar (NEXRAD) data. The MRLC dataset served as the land cover information and the STATSGO database was used to determine the hydrologic soil group for the analysis areas. Corrected NEXRAD data was used for daily precipitation information.

The runoff estimates for each grid cell were calculated using the Soil Conservation Service (SCS) Curve Number Method, which provides a means of estimating runoff based on land uses, soil types, and precipitation. This calculation is based on the retention parameter, S, initial abstractions, I_a (surface storage, interception, and infiltration prior to runoff), and the rainfall depth for the day, R_{day}, (all in mm H_2O).

The retention parameter is variable due to changes in soil type, land use, and soil moisture, and is defined as:

S = (1000 / CN-10), where CN is the assigned SCS curve number

For the runoff calculations, initial abstractions were approximated as $0.2S$, and NEXRAD rainfall maps were used to identify R_{day}. The runoff equation becomes:

$$Q_{surf} = (R_{day} - 0.2S)^2 / (R_{day} + 0.8\,S)$$

Runoff will occur only when $R_{day} > I_a$ (Neitsch et al., 2001).

A curve number (CN) grid was generated based on the MRLC and STATSGO datasets at a 100m × 100m resolution with the use of ESRI's ArcInfo and the ArcGIS 3.1.2 raster calculator. The CN was assigned based on average soil moisture conditions (Table 1), and then altered to account for the antecedent soil moisture conditions.

Table 1. Curve number assignments based on land use / land cover

Land Use/ Land Cover	Curve Numbers (Soil Hydrologic Group A, B, C, D)
Water	100
Urban	77, 85,90,92
Forest	36, 60, 73, 79
Rangeland	30, 58, 71, 78
Pasture	49, 69, 79, 84
Agriculture	67, 78, 85, 89
Wetland	100

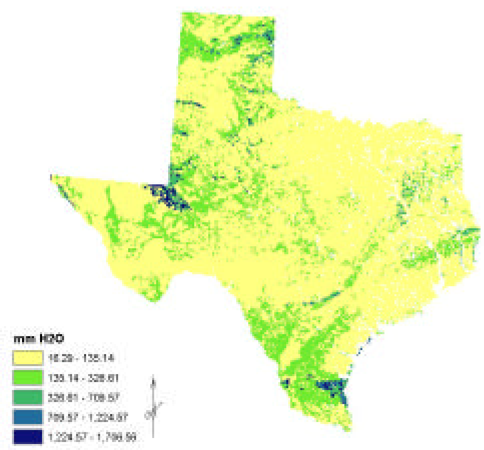
The antecedent soil moisture conditions were defined as dry (wilting point), average, or wet (field capacity), and were based on the previous five-day rainfall totals (Table 2) (Mitchell et al., 1993).

Table 2. Rainfall break points for antecedent soil moisture conditions.

Antecedent Moisture Conditions	Rainfall Range
I - Wilting Point	**< 12 mm**
II – Average	**12-41 mm**
III – Field Capacity	**> 41 mm**

An Arc Macro Language (AML) script and batch file was used with ESRI's ArcInfo software to make the daily calculations for the study period, April 1 - 15, 2002.

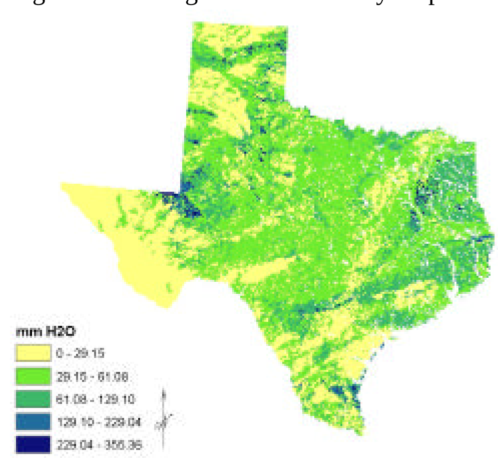
Figure 1. "True" runoff summary map.



First, the rainfall totals for March 27 - 30 were calculated. This information was then used to estimate the antecedent soil moisture conditions for April 1. Through the use of an "if-then" statement, the script then applied the appropriate *CN* grid to the NEXRAD rainfall data to calculate the "true" runoff for the current day. A batch file was then used to create a semi-automated way of processing the data for each consecutive day in the study period.

For comparison purposes, the runoff maps were re-calculated using only average antecedent soil moisture conditions, and summary and difference maps were generated for the two map sets. An additional AML was used to calculate total runoff for the "true" and average runoff datasets (Figures 1& 2). This same AML then subtracted the "true" runoff summary from the average runoff summary to generate a difference map (Figure 3).

Figure 2. Average runoff summary map.



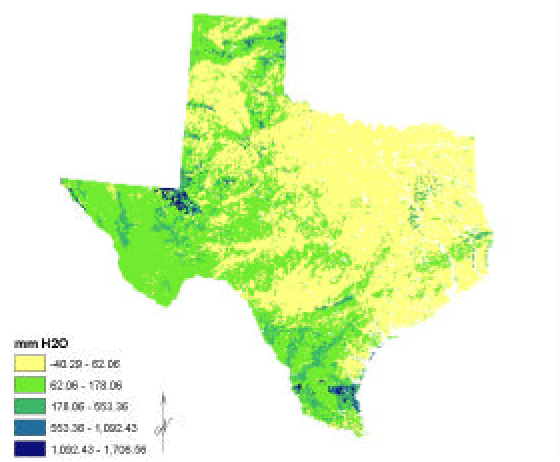
"True" runoff ranged from 16.29 – 1,706.56 mm, whereas average runoff ranged from 0 – 355.36 mm. The differences between the "true" and average summaries ranged from -40.29 – 1,706.56 mm.

Results and Discussions

Although the runoff vales estimated in this analysis have not been calibrated they do highlight the potential issues involved in estimating runoff without accounting for the antecedent conditions along with land cover and soil hydrologic group.

In general, the "true" runoff was substantially higher than the average values. In some cases however, the average calculations did generate higher runoff, as evidenced by the negative values in the difference map. This could be attributed to the fact that the antecedent soil moisture conditions were generally wetter than average, generating additional runoff when factored into the calculations, or dryer than average in the case of the over-estimated average runoff values.

Figure 3. Difference map: "true" – average runoff.



Although the runoff values generated here are not indicative of actual runoff values for Texas, they do illustrate the need for accurately estimating antecedent soil moisture conditions in surface runoff calculations.

Future Considerations

The results of this analysis need further calibration and validation to determine the appropriate rainfall break-points for various antecedent soil moisture conditions and to evaluate the accuracy of runoff estimates. The process of generating these maps must also be automated to achieve the ultimate goal of the research, which is a daily surface runoff map of Texas at a resolution of 4km × 4km. Once calibration and validation procedures are complete, these runoff maps would be made available on the World Wide Web (WWW) for use by public and private water resource managers and various government agencies.

References Cited

Mitchell, J.K., B.A. Engel, R. Srinivasan, R.L. Bingner, and S.S.Y. Wang, 1993. Validation of AGNPS for Small Mild Topography Watersheds Using an Integrated AGNPS/GIS. In Advances in Hydro-Science and Engineering, Volume I, ed. S.S.Y.Wang, 503-510. University, MS: Center for Computational Hydroscience and Engineering.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams, 2001. Soil and Water Assessment Tool Theoretical Documentation. Blackland Research Center, Texas Agricultural Experiment Station. Temple, Texas. 93-115.